COUNTER - THERMOSYPHON LOOP HEAT PIPE SOLAR COLLECTOR

BACKGROUND OF INVENTION

1. FIELD OF THE INVENTION

The present invention relates to a counter- thermosyphon loop heat pipe solar collector and particularly a counter- thermosyphon loop heat pipe solar collector that is capable of increasing thermal conduction effect, resolving heat loss problems resulted from liquid reversed flow at night time, and reducing costs.

2. BACKGROUND OF THE INVENTION

Using heat pipe on solar collectors is a research and design subject many people and institutions have pursued for decades. As solar collectors have large working area, how to reduce costs and make the structure simple becomes an important design direction. On the design of solar collectors, there are many issues pending to be resolved. For instance, there is still uncertainties regard liquid filling control, thermal leaking loss and thermal collector dimensions. Hence it is difficult to control quality during manufacturing processes. As a result, even under the excellent sunshine condition, over heat in the upper region of solar collector could happen and thermal efficiency will decrease.

Solar collector adopting counter-thermosyphon heat pipe (also called Anti-gravity thermosyphon heat pipe solar collector) was a mono-pipe heat pipe technology initially developed by American National Engineering Laboratory. The most advanced technology at present adopts loop heat pipe, and was developed by Institute of thermal physics, Ural branch of the Russian Academy of science, Ekaterinburg, Russia. The mono-pipe counter-thermosyphon heat pipe solar collector generally can utilize heat pipe submerged in water tanks or under forced convection. It has great restrictions in term of the shape. The technology of the mono-pipe heat pipe mainly

depends on heating liquid in the capillary on the heating side until boiling and expansion to squeeze working fluid out of the capillary into the heating side. The working fluid on the heating side absorbs heat and vaporizes, and flows into the cooling side for condensing, then flows into the capillary to complete a cooling and heating cycle.

The loop heat pipe technology developed by the Russian Academy of Science employs porous powder metallurgy sintered elements on the heating side. The porous powder metallurgy sintered elements provide capillarity and form vapor space between the heating side and cooling side. The heating side generates a large amount of heated and expanded vapor that cannot be cooled and condensed immediately on the cooling side. The heated and expanded vapor thus compress liquid on the cooling side to force a portion of the liquid flowing to another end of the heating side to complete cooling and heating circulation. However, during the night the temperature at the cooling side is higher than the heating side, liquid will flow back to the heating side (the heating side must be filled with liquid to prevent dry out). The siphon tube reversed flow will carry heat away and result in poorer effect. Moreover, the porous powder metallurgy sintered elements for providing capillarity are very expensive, and require several days of activation process after being filled with fluid. Thus the loop heat pipe is not desirable for use on solar collector.

SUMMARY OF THE INVENTION

The primary object of the invention is to provide an improved solar collector for resolving the problem of liquid reversed flow carrying away thermal energy during the night, and to provide heat pipe on the heating side and with capillary ejecting working fluid to produce film evaporation for increasing thermal efficiency.

Another object of the invention is to provide a solar collector that does not need the expensive porous powder metallurgy sintered elements and does not require reduction activation when in use, and may be produced at a lower cost than those adopted conventional techniques.

To achieve the foregoing objects, the invention provides a counter-thermosyphon loop heat pipe solar collector that mainly includes a

loop heat pipe which contains working fluid, a damper, a partition, a capillary, a heating apparatus and a cooling apparatus. The heating apparatus is located on a heating side of the heat pipe. The cooling apparatus is located on a cooling side of the heat pipe. The partition is located in the heat pipe on the heating side proximate to the bottom of the heat pipe for separating working fluid in the heat pipe. The capillary is vertically mounted to the partition and runs through the partition with two ends located on two sides of the partition. The damper is located at the top end of the capillary for preventing the working fluid from ejecting too high and flowing to the cooling side. The heating apparatus may be heated by natural resources (such as solar energy, geothermal energy, and the like). The cooling apparatus may use water or gas to carry away heat energy of the heat pipe for cooling.

As the damper is located at a top end opening of the capillary, working fluid ejected from the opening will be hindered and deflected to the sidewall of the heat pipe to generate film evaporation, thus can increase thermal conduction effect. Moreover, the partition is adjacent to the bottom end of the capillary for separating working fluid in the heat pipe. By means of such a construction, working fluid level below the partition may drop to the lowest level during night time and result in much lower thermal conduction, thus can resolve the problem of reversed flow liquid carrying away heat energy at night time.

In addition, the invention does not need the expensive porous powder metallurgy sintered elements and does not require reduction activation when in use, thus can be made at a lower production cost.

The foregoing, as well as additional objects, features and advantages of the invention will be more readily apparent from the following detailed description, which proceeds with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a counter-thermosyphon loop heat pipe solar collector according to the invention.

FIG. 2 is a schematic view of a plurality of heat pipe of the inventions coupled in series.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the counter-thermosyphon loop heat pipe solar collector of the invention consists of a loop heat pipe 1 which contains working fluid 7, a damper 2, a partition 3, a piping element 4, a heating apparatus 5A and a cooling apparatus 6A. In the embodiment discussed below, a capillary is used as the piping element 4 for an example. The working fluid 7 contained in the loop heat pipe 1 may be methanol or the like. The loop heat pipe 1 forms a closed loop space or is coupled with other loop heat pipe in series to form a closed loop space. The heat pipe 1 has a heating side 5 and a cooling side 6. The heating apparatus 5A (such as heating apparatus that utilizes solar energy, geothermal energy, industrial waste heat, etc.) is located on the heating side 5 to heat the heat pipe 1. The cooling apparatus 6A (such as apparatus that utilizes gas or water as working fluid) is located on the cooling side 6 to perform heat exchange with the working fluid in the heat pipe 1 for carrying away heat energy to achieve cooling effect. The heated cooling water or cooled air may be utilized as desired. The partition 3 is located in the heat pipe 1 on the heating side 5 proximate to the bottom of the heat pipe 1 for separating the interior of the loop heat pipe 1 on the heating side 5 to an upper zone 7A and a lower zone 7B. The capillary 4 is vertically mounted to the partition 3 in the loop heat pipe 1 and runs through the partition 3 with two opening ends 4A and 4B located respectively in the upper zone 7A and lower zone 7B. The capillary 4 may be in parallel with the direction of the tubular wall of the heat pipe 1 and gravity or form an angle therewith. The damper 2 is located at the top opening end 4A of the capillary for preventing working fluid 7 from ejecting too high and flowing to the cooling side 6. Furthermore, working fluid 7 may be deflected and spray to the wall of the heat pipe 1 because of the hindrance of the damper 2 so that working fluid 7 may flow downw place. When the working fluid is ejected from the top opening end of the capillary, the damper 2 may deflect the working fluid to flow downwards on the inner wall o ards along the pipe wall to generate film evaporation and result in greater evaporation effect.

According to the invention, the heating side generates heated vapor which is expanded to compress liquid on the cooling side, and the liquid being compressed is forced to flow in the capillary 4 and flow back to the heating side again thereby to form continuous cooling and heating circulation. The capillary 4 provides the function of channeling working fluid to the heating side. As liquid on the heating side is not compressible, vapor volume above the liquid may be expanded (within a constant space) to force the liquid on the cooling side moving downwards. The capillary 4 can transform the change of volume that is taking f the heat pipe on the heating side to generate film evaporation. Evaporation effect thus can be greatly enhanced. Hence heat pipe made of expensive porous powder metallurgy sintered elements may be dispensed with. Therefore this invention may be made with a lower production costs than those adopted conventional techniques.

In order keep liquid longer at the evaporation end to fully absorb heat for vaporizing and increase heat absorption power, the invention adopts a counter-thermosyphon (anti-gravity) heat pipe structure. In such a structure, liquid phase change zone is separated by the partition 3 in an upper zone and a lower zone. The upper zone and the lower zone are communicated by means of a narrow piping element or the capillary 4.

The counter-thermosyphon loop heat pipe solar collector of the invention has different operation conditions in daytime and nighttime. In daytime, the heating side may be heated by means of solar energy. Working fluid in the loop heat pipe 1 is vaporized to become vapor state. Because of the function of the partition 3, the vapor from the working fluid 7 in the upper zone 7A will form a driving pressure. As a result, the working fluid contained in the lower zone 7B will be forced to flow into the capillary from the bottom opening end 4B and eject out through the top opening end 4A, and hit the damper 2. Because of liquid gravity and the design of the damper 2, the ejected working fluid will be sprayed on the pipe wall and flow down along the pipe wall surface to produce heat exchange effect with the heating apparatus on the heating side. Hence a "film evaporation effect" will take place between the working fluid and the pipe wall to achieve a better thermal conduction effect.

At nighttime, the temperature on the cooling side is higher than the

heating side. Working fluid 7 in the upper zone 7A does not vaporize to become vapor. Hence working fluid may stay in the upper zone without flowing into the lower zone 7B. However due to siphon principle and capillarity, working fluid 7 in the lower zone 7B will still flow into the capillary from the bottom opening end 4B and eject out through the top opening end 4A. As a result, the amount of working fluid 7 in the lower zone 7B will gradually decrease until the working fluid level on the cooling side 6 is equal to the elevation of the partition 3. Hence at nighttime, the working fluid level under the partition 3 will drop to the lowest elevation, thus results in great decreasing of thermal conduction. Therefore the invention can overcome the problem of liquid reversed flow carrying away heat energy during night time that incurs to conventional techniques.

The counter-thermosyphon loop heat pipe solar collector of the invention may also be coupled in series by connecting a plurality of the heat pipe 1 through a duct 8 to increase heat collection effect. Referring to FIGS. 1 and 2, the heating apparatus 5A is mounted to the heating side 5 to heat working fluid 7 contained in the heat pipe 1 to become vaporstate (it is to be noted that construction relationship between the heating apparatus or the cooling apparatus and the heat pipe in FIG. 2 is different from what is shown in FIG.1). The cooling apparatus 6A utilizes water or gas to carry away heat energy in the heat pipe on the heating side to generate continuous cooling and heating circulation. When working fluid 7 in the upper zone 7A of the heating side 5 is vaporized to become vapor, the vapor will flow to the cooling side 6 and compress working fluid in the cooling side. Then cooling water or gas in the cooling apparatus 6A on the cooling side 6 will proceed heat exchange with the heat pipe 1 to carry away heat energy. After heat exchange is completed, vapor in the heat pipe 1 is condensed to become liquid and flows to the lower zone 7B to join working fluid contained therein. Working fluid 7 in the lower zone 7B then may be siphoned through the capillary 4 to the upper zone 7A again for heating, thus to form a cooling and heating circulation.

While the preferred embodiment of the invention has been set forth for the purpose of disclosure, modifications of the disclosed embodiment of the invention as well as other embodiments thereof may occur to those skilled in the art. Accordingly, the appended claims are intended to cover all embodiments that do not depart from the

spirit and scope of the invention.